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# Environmental Effects of Dredging Technical Notes



## SELECTING EQUIPMENT FOR USE IN DREDGED MATERIAL CONTAINMENT AREAS

PURPOSE: This technical note describes methods for selecting appropriate equipment for use in dredged material containment areas. It also briefly describes the types of equipment currently being successfully used in these areas.

BACKGROUND: Management of confined upland dredged material containment areas, to dewater the material and improve its engineering properties, requires use of large equipment for activities such as surveying, trenching, and earthmoving. Because dredged material enters the containment areas as a slurry and subsequently is dried to form a stiff crust overlying softer material, its structure poses many challenges not normally encountered in conventional earthwork. Therefore, selection of equipment must be made based on not only the normal considerations for equipment selection (i.e., use, availability, and capacity), but also on dredged material site conditions. Techniques for assessing equipment mobility and performance have been developed and documented. Empirical data also can provide some initial guidance on equipment selection and timing of initial management activities.

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## Introduction

Upland dredged material containment areas are being managed more intensively than ever before because of the scarcity of land for new disposal sites and expense of developing these sites as well as the scarcity of remaining storage capacity in existing sites. The purposes of managing the sites include increasing site capacity by densifying the material to be stored (i.e., removing

water from the mass), improving material properties thus allowing removal and use of the material, and allowing ultimate beneficial use of the site itself (Poindexter-Rollings 1989). To meet these purposes, the dredged material must be dewatered. A number of techniques are available for dewatering and improving engineering properties of dredged material and other soft soils (Headquarters, US Army Corps of Engineers 1986; Benson 1988; Rollings, Poindexter, and Sharp 1988). All improvement techniques require construction equipment, and selection of appropriate equipment is important.

## Typical Site Conditions

Sites used to contain dredged material normally pose problems not often encountered in earthwork construction. The dredged material is typically placed in a confined upland site by hydraulic pipeline dredge; the material enters the site as a slurry with a concentration of about 150 g/ℓ (which is equivalent to a dry unit weight of approximately 9 lb/cu ft). As dewatering begins through removal of ponded surface water and evaporative drying of the dredged material, a crust forms on the surface of the material. After a summer drying period of about 3 months, the crust normally has sufficient depth and strength to support a person. At this point in crust development, the crust typically has a water content of about 1.2 times the water content at the material's plastic limit ($1.2 \times PL$). The material below the crust is usually at a water content of 1.8 times the material's liquid limit ($1.8 \times LL$); the subcrust material will stay in this condition indefinitely unless the dredged material layer thickness is very small (less than 3 ft initially) thus allowing the entire thickness to dry or other methods of dewatering (besides evaporative drying) are instituted. (The Atterberg plastic limit is defined as the water content at which the soil ceases to be in a plastic state and starts to crumble. The Atterberg liquid limit is the water content at which the soil and water start to flow as a viscous liquid.) The depth to which surface crust will form depends on dredged material properties, disposal site drainage conditions, and environmental factors such as precipitation and evaporation. Typically, ultimate crust thickness in sites subjected only to evaporative drying ranges from 8 to 15 in. (Please note that ultimate crust thickness corresponds to a much greater initial thickness; for instance, an ultimate crust thickness of 8-15 in. might result from initial

placement of 1 ft to several feet of slurry. Thus, a direct comparison cannot be made between initial and ultimate thicknesses.)

As seen from the preceding discussion, the stratigraphy of dredged material containment areas can be very different from that normally encountered in the field, with the strongest material on the surface and softer material below. If a disposal site has been used for multiple disposal operations, the stratigraphy of the site can be very complex. Because of these site conditions, special techniques must be used to evaluate the potential mobility of construction equipment in these areas.

## Equipment Evaluation Techniques

The most quantitative evaluation technique for assessing equipment mobility in dredged material containment areas is one developed by Willoughby (1977, 1978) during the Dredged Material Research Program (DMRP). It was developed by modification of an existing NATO Reference Mobility Model (NRMM), which is a user-friendly version of the Army Mobility Model (AMM). These models evaluate soil strength with depth and use the strength of the "critical" layer to predict vehicle mobility across a soil deposit. The major modification required for application to dredged material was recognition that the critical layer, i.e. the weakest layer, is not necessarily located at the surface of the ground. This evaluation technique can be used to predict the performance of equipment used for conducting various work functions in a containment area, specifically single-pass and multiple-pass operations (Headquarters, US Army Corps of Engineers 1978).

To evaluate the potential for equipment mobility, field data on soil strength must be collected. These data include the cone index (CI) and the remolding index (RI), which are obtained by pushing a hand-held cone penetrometer into, respectively, the in-situ dredged material and a remolded (compacted) specimen of dredged material. These data are then used to calculate the rating cone index (RCI), which gives an indication of the strength of the soil. The procedures are repeated at various depths and locations throughout the containment area to provide a picture of soil strength across the entire area. These data can then be compared to data for specific peices of equipment, which indicate soil strength required to support the vehicle. Procedures for using this

equipment evaluation technique are discussed and vehicle data are given by Willoughby (1977, 1978), Green and Rula (1977), and Poindexter (1989).

## Empirical Approach

At times, a District office may not have the resources available to conduct an equipment evaluation as described above, or the District may not have had experience with using equipment on dredged material and may want a very tentative indication of dredged material conditions before initiating an evaluation. In either case, some approximate correlations, or indicators of soil strength, are given in Figure 1. Since these correlations were developed for soils other than dredged material deposits and should be applied to the "critical" layer for equipment mobility considerations, it may be more useful to apply them to the subcrust dredged material. Also a very simple test can easily be conducted to give a rough indication of the soil support to be expected from the material in its present condition: a person can attempt to walk on the dredged material surface. A rule of thumb is that if a person can walk on the dredged material surface, then low-ground-pressure equipment can work on it.*

To be somewhat more quantitative, a few calculations can be made which may give an indication of the pieces of equipment that can or cannot operate on the dredged material surface at the time and dredged material condition of the empirical test. Divide the weight of the person who walked on the dredged material surface by the contact area of the sole of his/her shoe (in square inches). This will yield the ground-contact pressure of the individual which can then be compared to the manufacturer's specifications for various equipment. Any vehicle with an equal or lower ground-contact pressure can probably be used for a single-pass operation in the disposal area. Some typical values for individuals' ground-contact pressures (Rush and Rula 1967) are given in Table 1.

Several cautions must be remembered regarding this empirical approach. This approach gives a very rough indication of site conditions and thus potential vehicle mobility; it should not be used to determine when to initiate operations in a site nor to select specific pieces of equipment, but simply to provide tentative guidance on when to conduct an equipment evaluation. This approach

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* James E. Walker, July 1988, Operations Division, US Army Engineer District, Mobile, Mobile, AL.

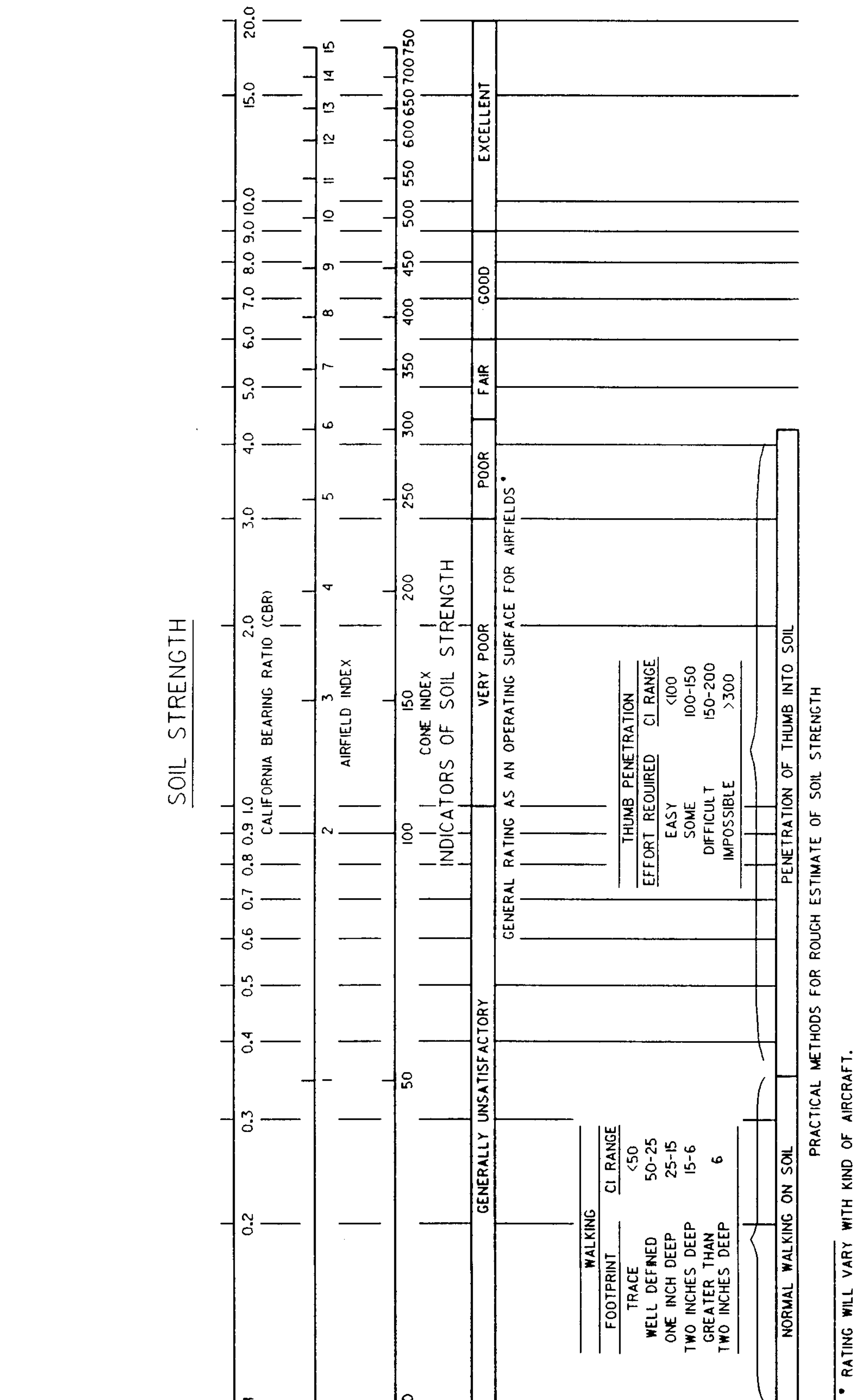


Figure 1. General correlations between soil strength and practical indicators of soil strength (modified from Hammitt and Rollings 1987)

Table 1

Examples of Ground-Contact Pressure for Individuals

| Individual | Height in. | Weight lb | Area on One Footprint, sq in. | Ground Contact Pressure, psi |
|---|---|---|---|---|
| 1 | 67 | 159 | 34.0 | 4.7 |
| 2 | 68 | 154 | 32.0 | 4.8 |
| 3 | 69 | 168 | 32.7 | 5.1 |
| 4 | 75 | 187 | 34.7 | 5.4 |
| 5 | 68 | 166 | 31.2 | 5.3 |
| 6 | 68 | 167 | 32.7 | 5.1 |
| Average | 69 | 167 | 32.9 | 5.1 |

only gives tentative guidance regarding conditions in the areas where the individual walked. Also, soft spots normally occur within a dredged material containment area (especially near the weir and in corners of the site) and may cause equipment mobility problems. This empirical test does not indicate whether a working platform, or mat, will be needed below the equipment to reduce the vehicle ground-contact pressure; additional field experience (empirical data) or the equipment evaluation technique previously described will be required. Mats are normally needed if the soil strength available is near the soil strength required to support the vehicle for its intended use. If a vehicle will be working in a stationary position or in some manner will be disturbing the soil with eccentric loadings or side-to-side movements, then mats are normally needed. If mats are needed, any type of platform may be used that can distribute the weight of the vehicle over a larger area and that is easy to place and move in the containment site. The following materials have been successfully used as a working platform in dredged material containment areas: timber or log rafts, landing mat, and 3/4-in. marine plywood (for an expendable mat).

## Equipment Used by Districts

The equipment used in dredged material containment areas is usually low-ground-pressure construction equipment. Typical vehicles used during dredged material dewatering activities include draglines, backhoes, bulldozers,

mini-excavators, and trenchers (such as Ardco or Gemco). Draglines are often used to dig perimeter trenches in the containment area while working from the perimeter retaining dike or a berm inside the dike. Backhoes and mini-excavators are used to dig trenches throughout the site or to clear trench intersections. Bulldozers are initially used to spread material placed by draglines on the inside of dikes during perimeter trench construction; they are later used to windrow dewatered material for removal from the containment area. The trenchers are used to pull rotary ditchers (such as Donde) to create trenches throughout the disposal site. Examples of equipment working in dredged material containment areas are shown in Figures 2 through 5.

After dredged material has dried, the dewatered material is often scraped from the surface of the deposit and is removed from the site for various beneficial uses. The equipment mentioned above is then supplemented with scrapers and possibly larger hydraulic excavators. Dry material is normally windrowed before removal by a scraper, as shown in Figure 6.

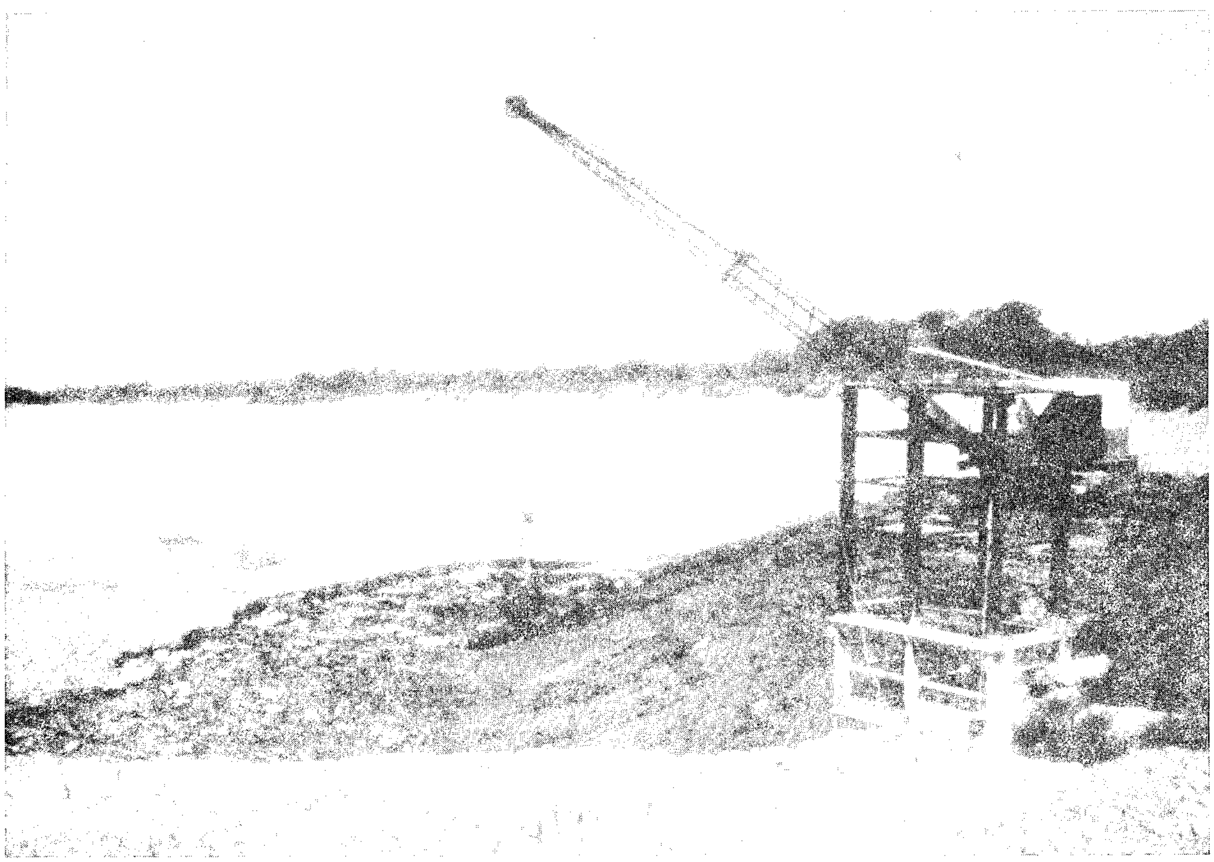

Figure 2. Dragline working from berm to create perimeter trench and sump near weir (courtesy of Charleston District)

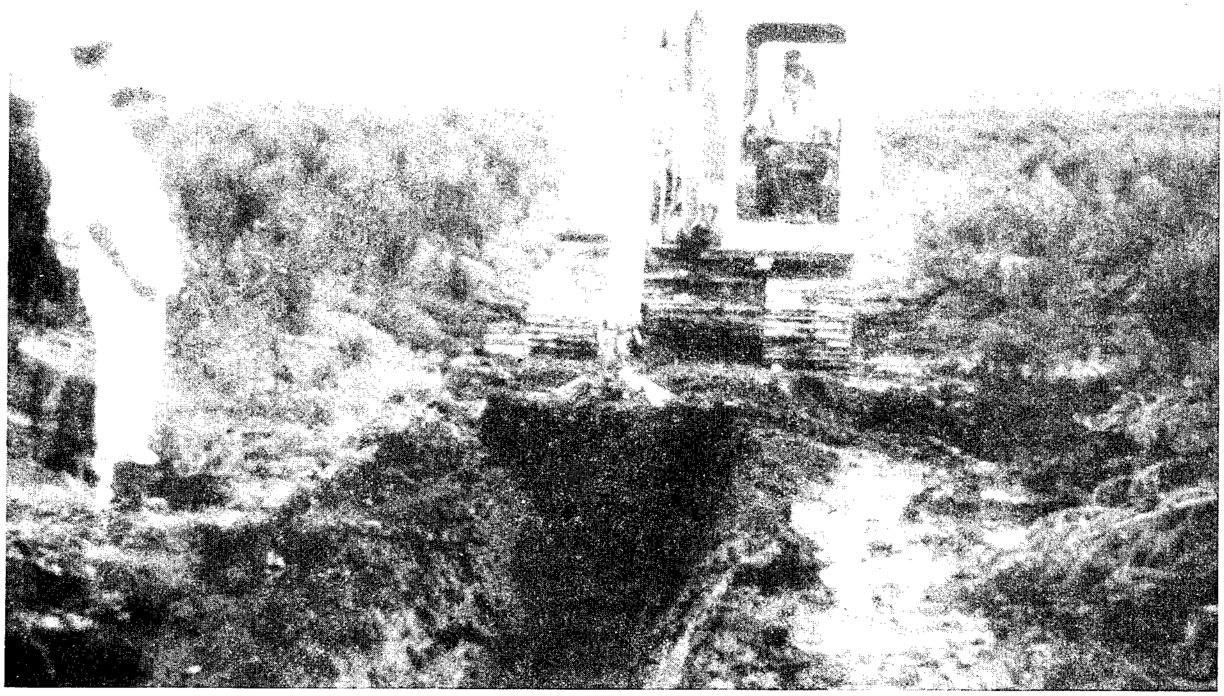

Figure 3. Mini-excavator operating on wooden mats to dig interior trench; notice the trapezoidal bucket (courtesy of Mobile District)

Figure 4. Trencher with rotary ditcher lifted between trenching operations

Figure 5. Bulldozer scraping dried material from the dredged material surface (courtesy of Charleston District)

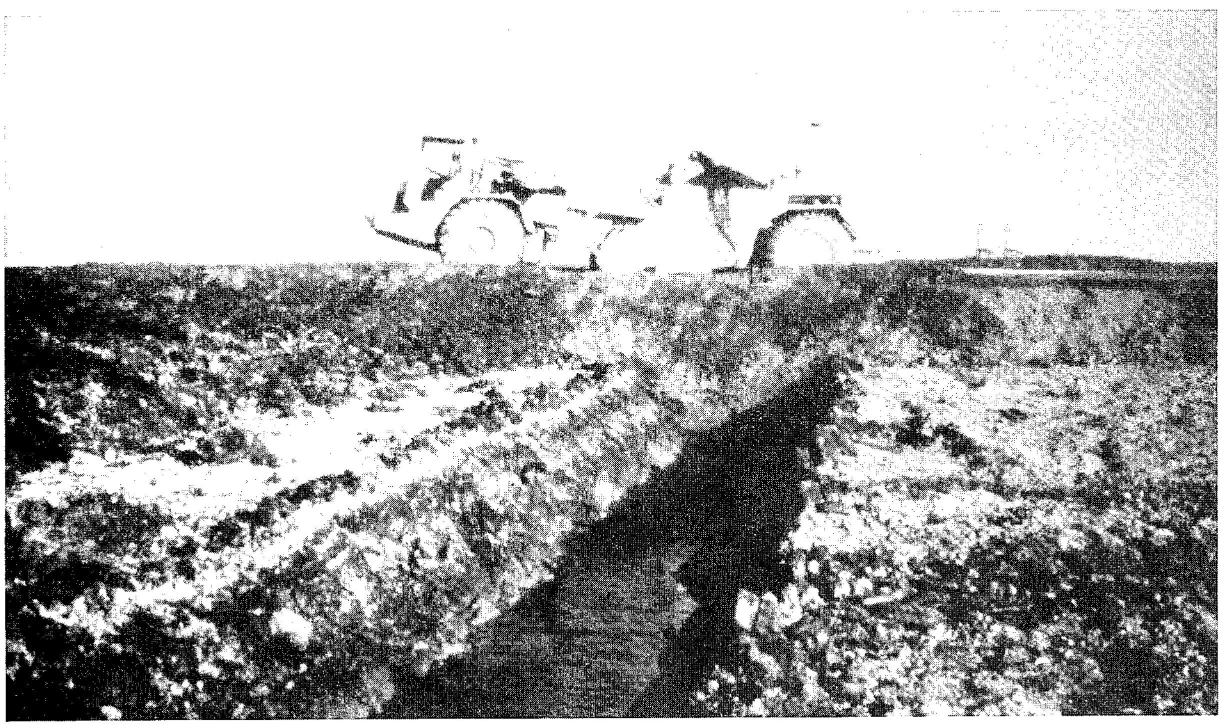

Figure 6. Scrapers removing dewatered and windrowed material from the site for dike improvement (courtesy of Charleston District)

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